Development of an Extremely Durable Concrete (EDC)

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Team Members:
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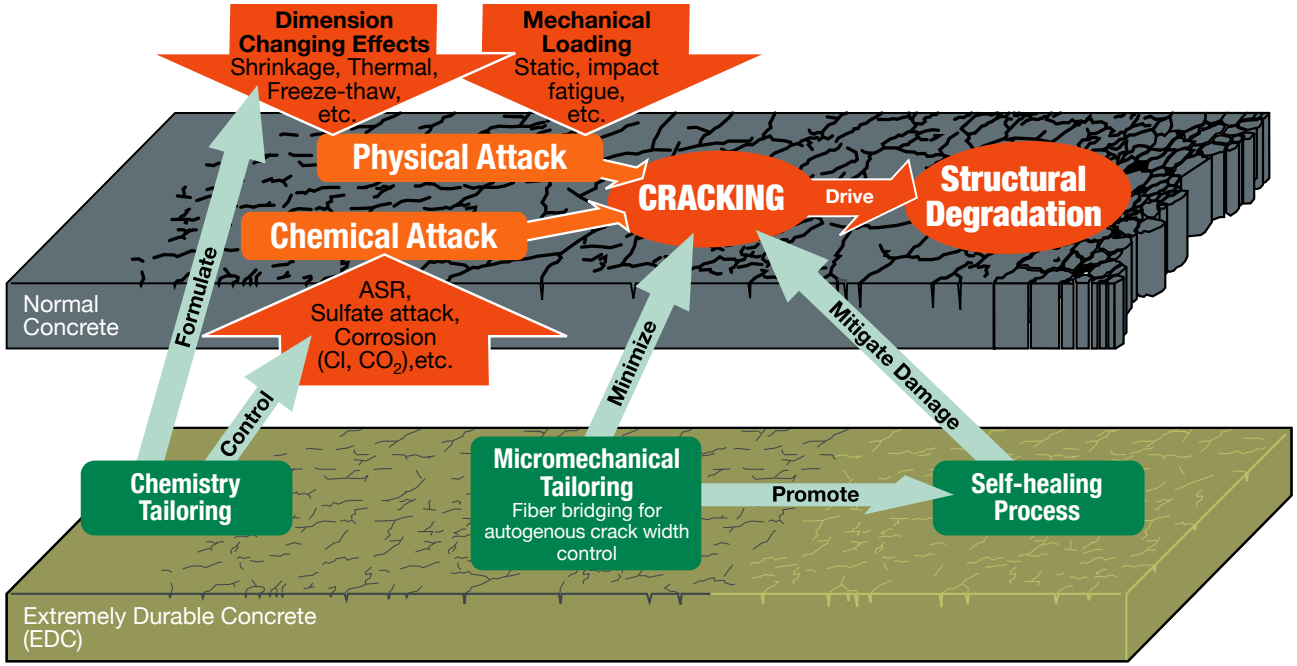
Project Goal

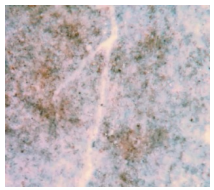
Enhancing concrete infrastructure service life by 5-fold

Total project cost:	$1.9M
Current Q / Total Project Qs	Q9 / Q12

TINA-Cement
Annual Meeting
October 13 & 14, 2021

The Concept – *Enhancing durability by chemistry and crack control*





Current infrastructure: **Cracking** is a key structural degradation mechanism; unreliable control

Future infrastructure: **Crack control** and self-heals

Result: No repeated repairs, lowers energy consumption and O&M cost of infrastructure

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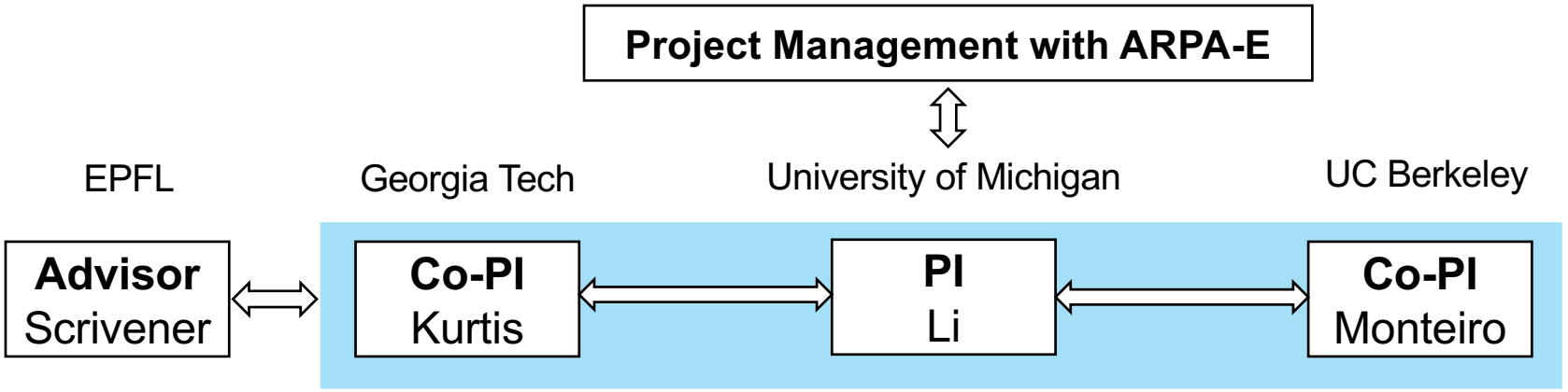
The Team



Sub-groups	Main focus
Michigan Group	Project coordination, composite development and extreme durability investigation and verification
Georgia Tech Group	Cement chemistry, particle packing, and durability
Berkeley Group	Micro- and nano- characterization

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Project Objectives – *A suite of EDC products within 2 years*

Goal: To achieve an EDC with life expectancy *five times* that of current concrete

Duration: 2 years (10/2019 – 09/2021)

Final Deliverables:

- Compressive strength: three levels > 20 MPa, 30 MPa and 40 MPa
- Tensile ductility > 3%
- Crack width < 50 μm

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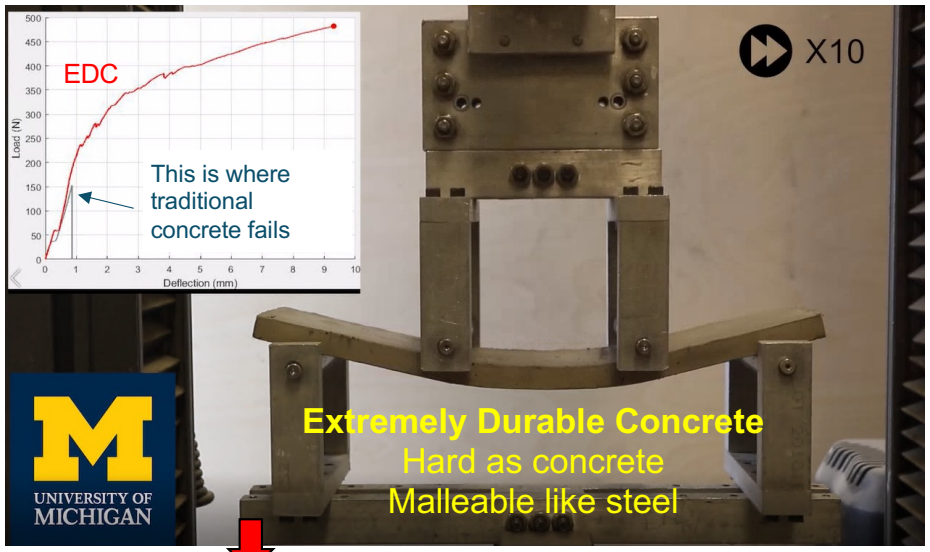
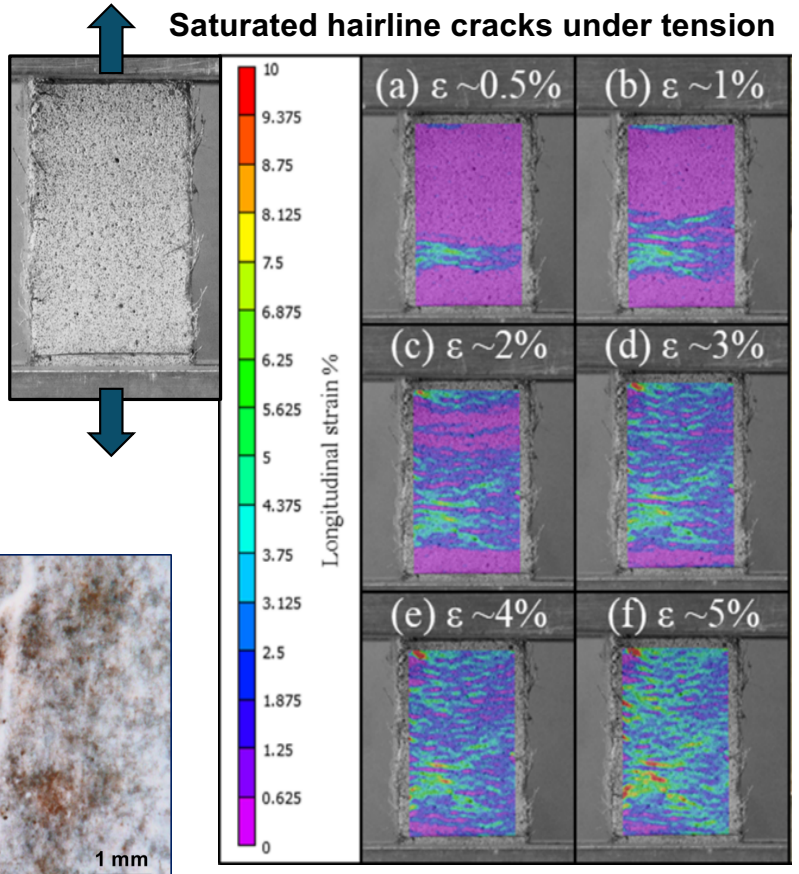
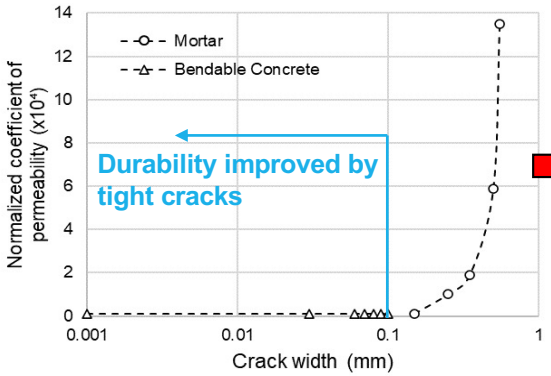
Multiple fine cracks achieved by micromechanical design

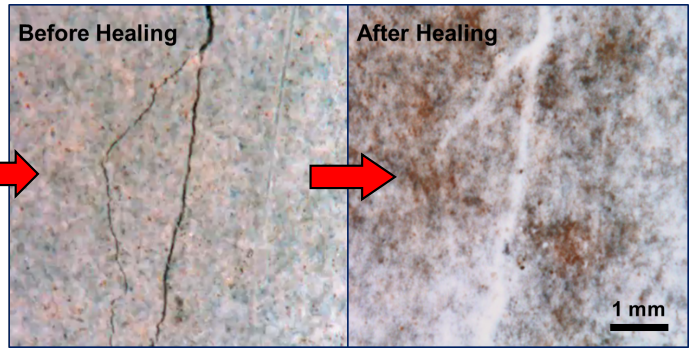


Saturated hairline cracks under tension



Water Permeability coefficient





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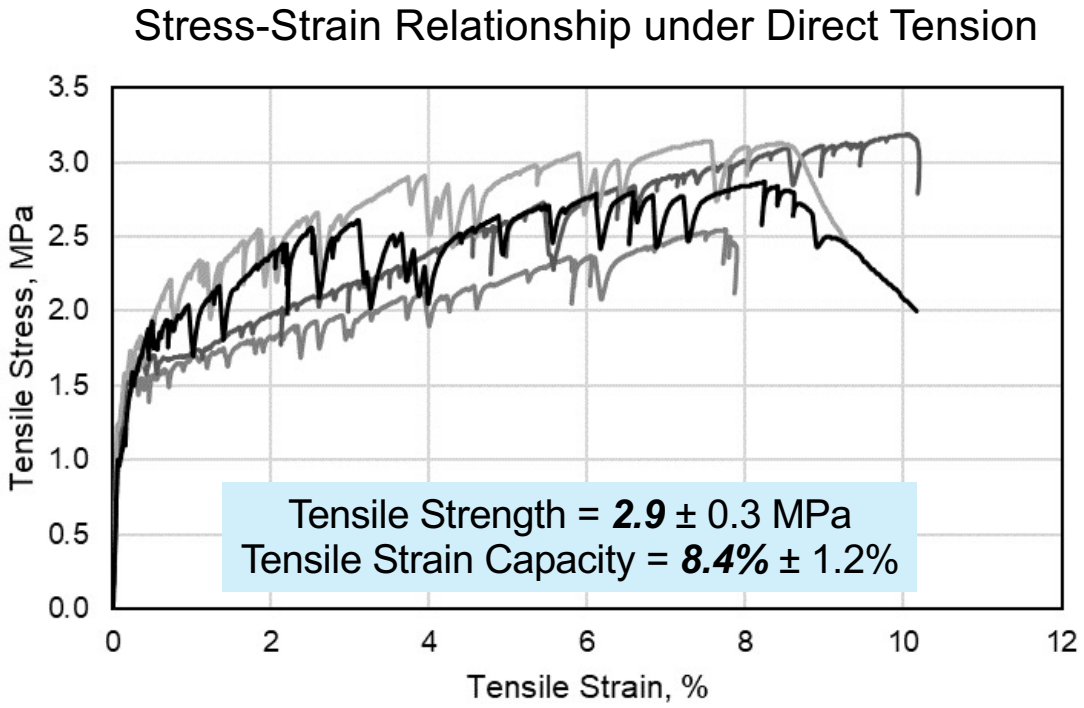
EDC attains tensile ductility up to 8%



Ingredients
Portland Cement
Fly Ash
Metakaolin
Limestone
Silica Sand
Water
HRWRA
Polypropylene Fiber

Air Cured for 28 Days; Loaded at 0.5 mm/min

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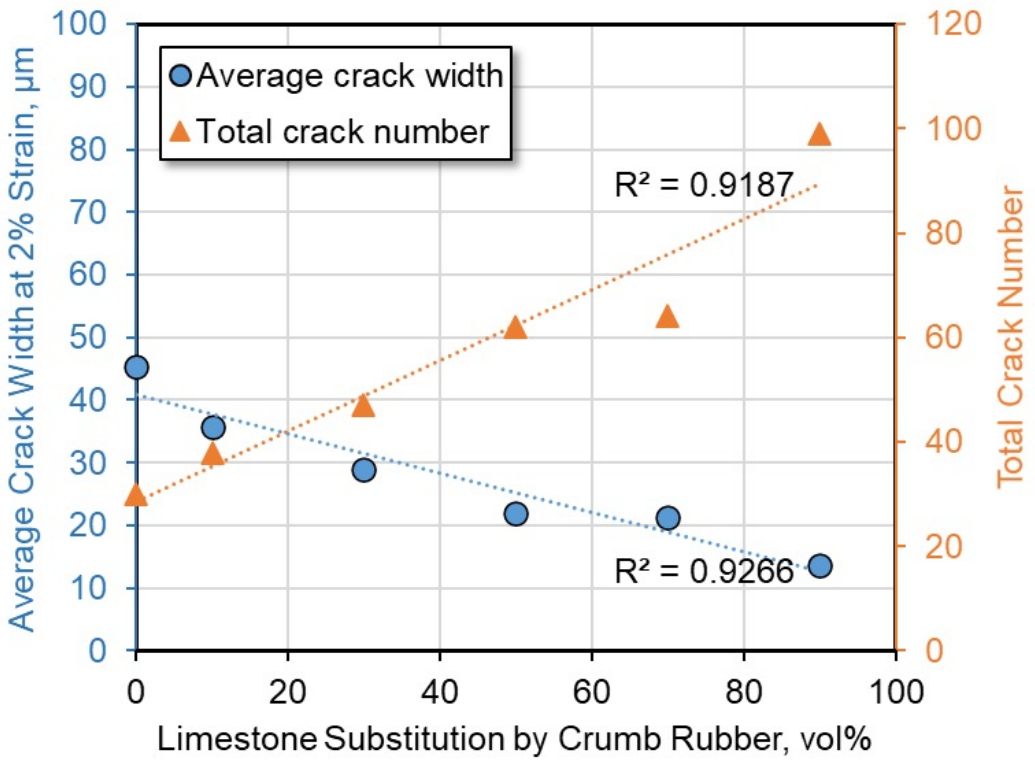
Crack width controlled below 50 μm using waste tire rubber



EDC crack pattern at 2% tensile strain

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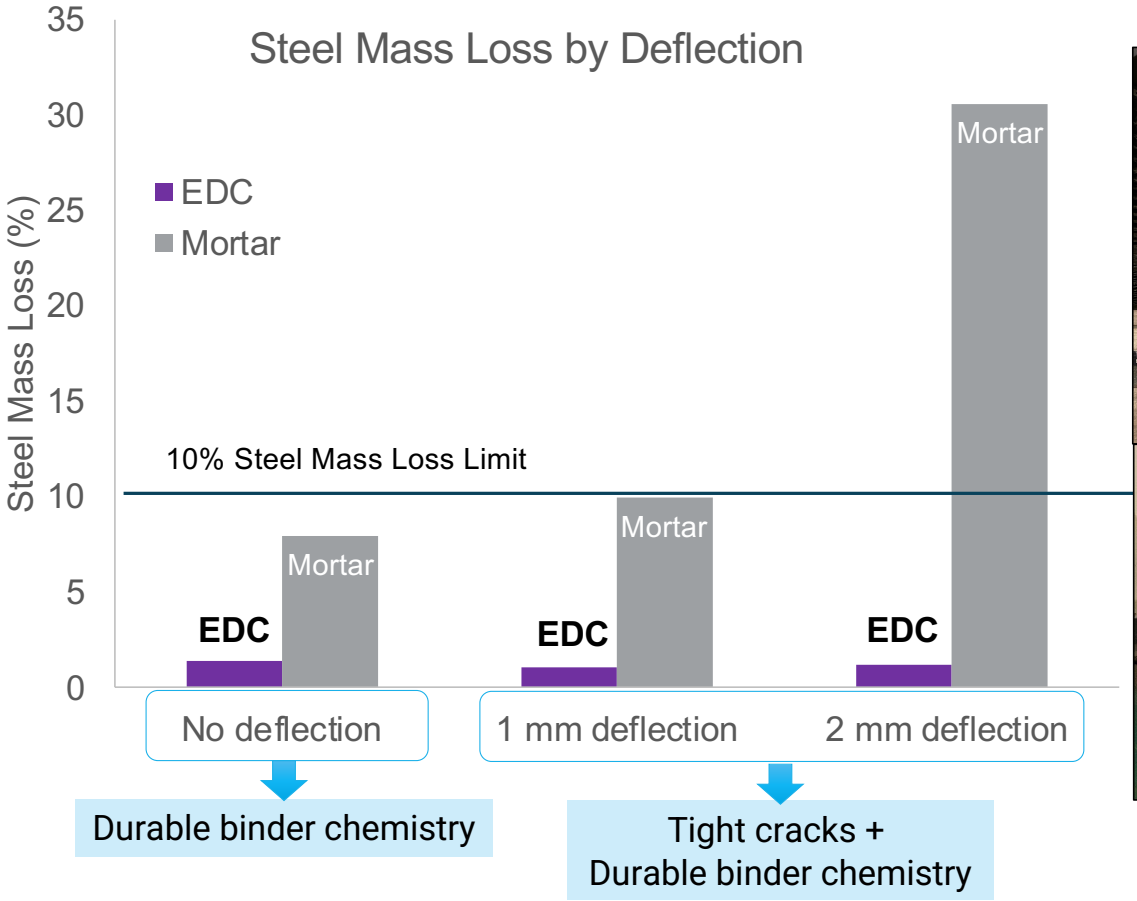
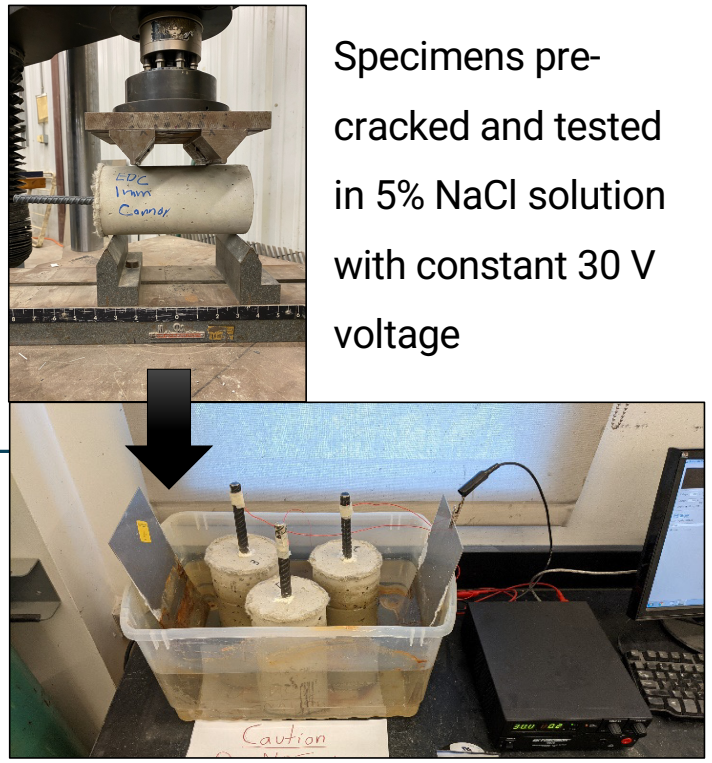
Tight cracks slow down steel rebar corrosion substantially





Specimens pre-cracked and tested in 5% NaCl solution with constant 30 V voltage

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Technology-to-Market

- Commercialization Plan
  - **Technology**: Extremely durable concrete (EDC) for general civil infrastructure and critical energy infrastructure applications
  - **Route**: Licensing
  - **Timeline**: 1) Industry focus group [2020], 2) Prototyping and demonstration [in progress], and 3) Market penetration [2022]
  - **Required Resources**: Engagement of early adopters with expertise in design and construction; Policy support by public agency such as DOTs and cities/counties to lower the risk for early adopters
  - **Potential Applications and Adopters**: Highway and roadway, bridge, pipeline, general repair application, critical energy infrastructure (such as nuclear plant), etc.

Summary Slide

- **Concept**: By coupling fiber bridging and durable binder chemistry, EDC develops ultrahigh ductility (up to 8%) and intrinsically tight crack width (<50 μm)
- **Final goal**: A complete set of extremely durable concrete for industrial adoption
- **Where we are**: Material testing for extreme durability and self-healing capability

We welcome collaborations with partners involved in construction value chain

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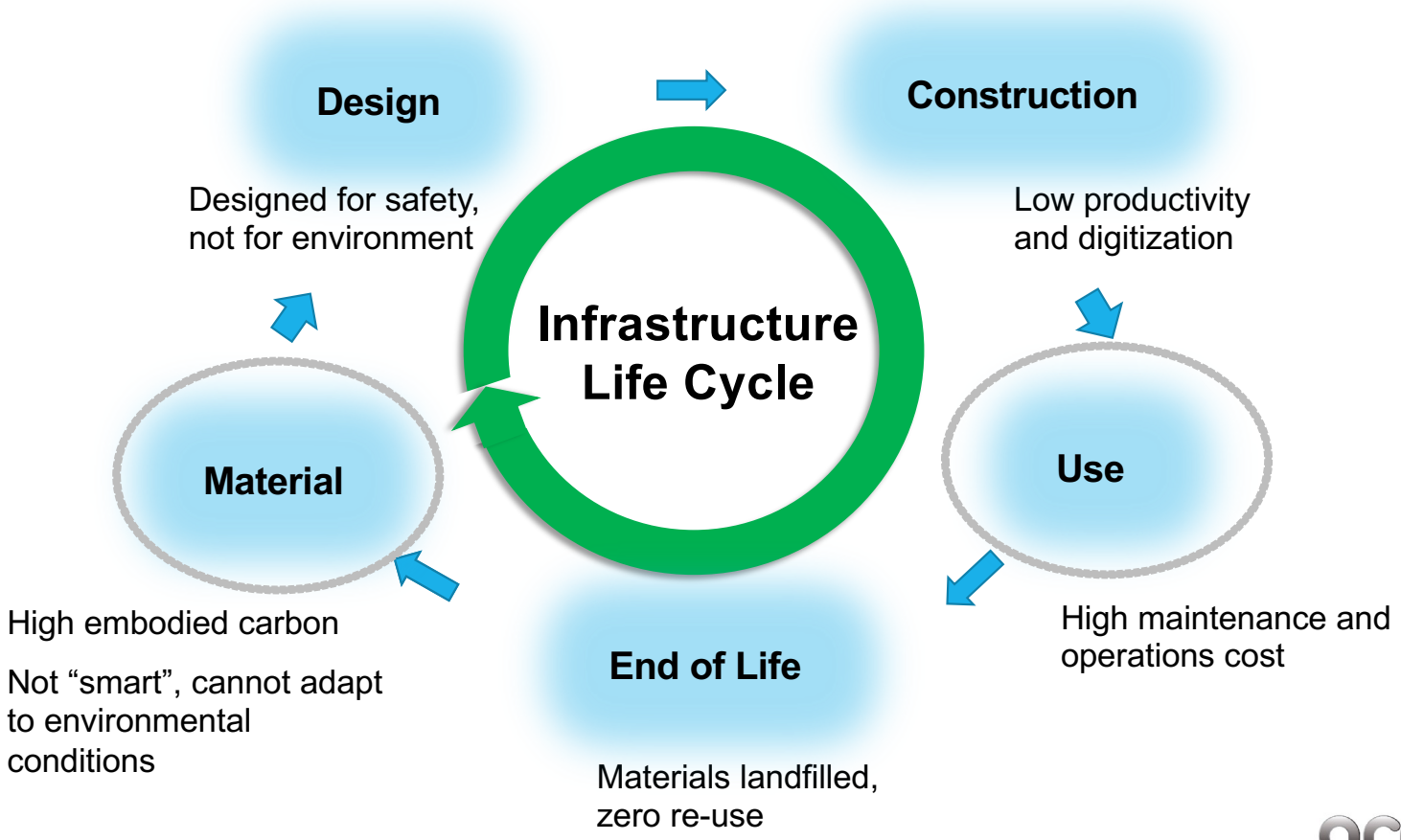
Low embodied and operational carbon infrastructure



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ENERGY

https://arpa-e.energy.gov